

# Improved Foreign Object Damage Performance for 3D Woven Ceramic Matrix Composites, Phase II

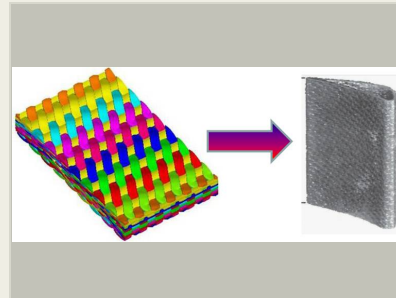
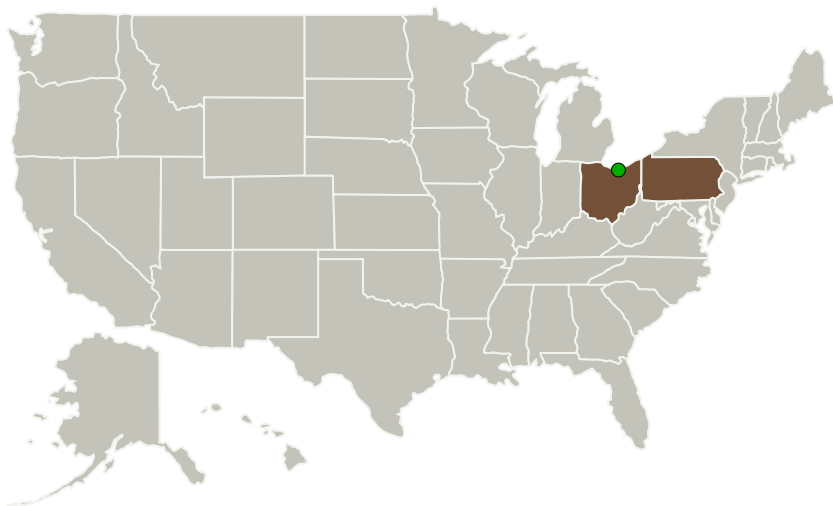
Completed Technology Project (2014 - 2016)



## Project Introduction

As the power density of advanced engines increases, the need for new materials that are capable of higher operating temperatures, such as ceramic matrix composites (CMCs), is critical for turbine hot-section static and rotating components. Such advanced materials have demonstrated the promise to significantly increase the engine temperature capability relative to conventional super alloy metallic blades. They also show the potential to enable longer life, reduced emissions, growth margin, reduced weight and increased performance relative to super alloy blade materials. MR&D is proposed a program focused on improving the impact resistance of CMCs using 3D woven reinforcement. This approach was shown in the Phase I program to hold promise for increased performance is of specific interest to Rolls Royce as a candidate material for vanes and blades in their turbine engines. MR&D will expand the capability of its analysis tool which was developed during the Phase I program by incorporating failure criteria tailored for 3D woven preforms as well as executing analyses to predict the exact locations of the fiber tows after weaving. Along with impact testing, an expansive testing program to characterize multiple 3D fiber architectures will be executed. The impact testing and associated non-destructive evaluation will be conducted at the University of Akron using state-of-the-art techniques to record the damage caused by the projectile in real time as well as detailed post-test evaluation. Material characterization tests will be conducted at Southern Research Institute and The Ohio State University. All of the data resulting from this extensive test program will enhance the analytical tools accuracy and utility.

## Primary U.S. Work Locations and Key Partners



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Organizations Performing Work	Role	Type	Location
Materials Research and Design, Inc.	Lead Organization	Industry	Wayne, Pennsylvania
● Glenn Research Center(GRC)	Supporting Organization	NASA Center	Cleveland, Ohio
University of Akron Main Campus	Supporting Organization	Academia	Akron, Ohio

## Primary U.S. Work Locations

Ohio	Pennsylvania
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## Project Transitions

▶ **September 2014:** Project Start

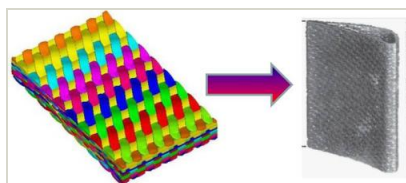
✓ **November 2016:** Closed out

**Closeout Summary:** Improved Foreign Object Damage Performance for 3D Woven Ceramic Matrix Composites, Phase II Project Image

**Closeout Documentation:**

- Final Summary Chart Image(<https://techport.nasa.gov/file/137565>)

## Images

**Briefing Chart Image**

Improved Foreign Object Damage Performance for 3D Woven Ceramic Matrix Composites, Phase II  
(<https://techport.nasa.gov/image/135926>)

## Organizational Responsibility

**Responsible Mission Directorate:**

Space Technology Mission Directorate (STMD)

**Lead Organization:**

Materials Research and Design, Inc.

**Responsible Program:**

Small Business Innovation Research/Small Business Tech Transfer

## Project Management

**Program Director:**

Jason L Kessler

**Program Manager:**

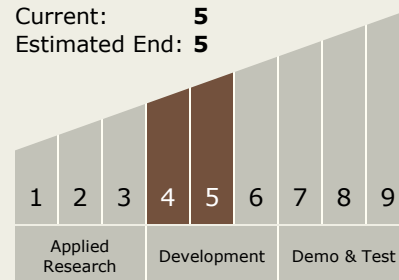
Carlos Torrez

**Principal Investigator:**

Edward J Klock-mccook

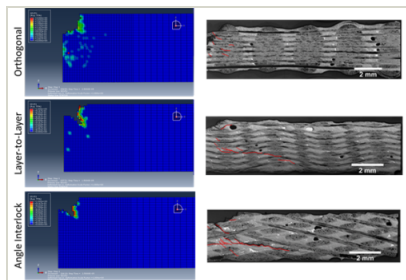
## Technology Maturity (TRL)

Start: 4  
Current: 5  
Estimated End: 5



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## Final Summary Chart Image

Improved Foreign Object Damage Performance for 3D Woven Ceramic Matrix Composites, Phase II Project Image

(<https://techport.nasa.gov/image/132541>)

## Technology Areas

### Primary:

- TX12 Materials, Structures, Mechanical Systems, and Manufacturing
  - └ TX12.1 Materials
    - └ TX12.1.4 Materials for Extreme Environments

## Target Destinations

The Sun, Earth, The Moon, Mars, Others Inside the Solar System, Outside the Solar System